

BODY MASS AND CARCASS COMPOSITION OF FALL MIGRANT OLDSQUAWS

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ABSTRACT.—We investigated body and organ mass and carcass composition of twenty-seven migrant Oldsquaws (*Clangula hyemalis*) killed when they collided with power transmission lines in northeastern Ontario in October 1986. Comparison of the first principal component (PC1) from eight structural measurements indicated that adult male Oldsquaws were structurally larger than females; however, organ weights did not differ between sexes when PC1 was included as a covariate (ANCOVA, $P > 0.05$ in all cases). Carcass composition was similar to that reported for spring migrants. Ash-free lean dry weight (AFLDW) and ash were positively related to structural size, but did not differ between sexes when PC1 was included as a covariate. Lipids comprised 17.5% of whole body mass of females and 14.1% of males and were sufficient to fuel migration at least to the next likely staging area in the Great Lakes. Fall migrant Oldsquaws must have stored substantial lipid and protein reserves after breeding, suggesting that offshore feeding areas in James and Hudson Bay are critical. Received 9 Oct. 1995, accepted 1 Feb. 1996.

Oldsquaws (*Clangula hyemalis*) are small-bodied sea ducks that breed around Hudson Bay and across the Arctic and winter along the Atlantic and Pacific coasts and on the Great Lakes (Bellrose 1978). Peterson and Ellarson (1979) reported changes in carcass mass and composition of Oldsquaws between December and July. Their data were collected from wintering birds drowned in gill nets on Lake Michigan and from birds shot on a breeding area in northwest Hudson Bay. They found two peaks in carcass mass that were primarily associated with increased lipid deposits. Peak body mass occurred just before spring migration in May and in January, a time when Oldsquaws sometimes endure periods of thermal stress caused by low temperatures (Peterson and Ellarson 1979). However, carcass composition and body mass data are not available for Oldsquaws during the postbreeding period and fall migration. It is important to understand changes in body mass and carcass composition throughout the annual cycle to identify critical periods for weight gain. The purposes of this paper are to report body size and carcass composition for a sample of Oldsquaws obtained during fall migration in northeastern Ontario and to compare our data to those from Peterson and Ellarson (1979).

METHODS

We obtained 27 adult Oldsquaw carcasses from the Smoky Falls hydroelectric dam located on the west bank of the Mattagami River in northeastern Ontario (50°04'N, 82°10'W). The

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birds were killed during an apparent migration movement at around 22:00 h on 26 October 1986 when they hit power transmission lines spanning the river. All birds were frozen and shipped to the University of Western Ontario for carcass analysis. Whole Oldsquaw carcasses were thawed and weighed to the nearest 0.1 g (hereafter referred to as whole body mass) on a Mettler digital balance. Following Dzubin and Cooch (1992), we measured bill depth at the base, maximum bill width, culmen l, tarsus bone, and exposed keel lengths to the nearest 0.1 mm, using Vernier calipers, and wing chord and total body length to the nearest mm using a ruler. We also measured wing length, from the body to the distal end of the outstretched wing, to the nearest mm using a ruler. Next we obtained carcass mass (whole body minus head, feet, wings, feathers, gastrointestinal tract, and reproductive organs) for comparison to data presented by Peterson and Ellarson (1979). All internal organs (except lungs and kidneys) and abdominal fat were dissected from the carcasses, patted dry with paper towels, and weighed to the nearest 0.01 g; contents were removed from gastrointestinal organs before weighing.

Our carcass composition analyses were designed to provide data comparable to those of Peterson and Ellarson (1979), but we also analyzed breast, leg, and liver tissues separately and included results from a combined homogenate of the head, feet, wings, feathers, gastrointestinal tract minus contents, and reproductive organs (hereafter called "dry parts"). The latter procedures provided data for whole birds for future comparisons. Combined values from breast, leg, liver, and carcass homogenate (but not dry parts) are equivalent to the "carcass" values from Peterson and Ellarson (1979). Samples were ground twice in a Hobart meat grinder and oven dried at 90°C to constant weight (Kerr et al. 1982). Dried carcass homogenate, dry parts homogenate, breast, leg, and liver samples were then homogenized separately in an electric coffee grinder. Lipid extractions were performed on subsamples (ca 10 g) of each constituent in a modified Soxhlet apparatus using petroleum ether as a solvent (Dobush et al. 1985). We determined the proportion of lipid in each subsample and multiplied this by the dry mass of each constituent sample to determine lipid mass. Lipid mass was then subtracted from dry weight of each constituent to estimate lean dry mass (LDM; Ankney and Afton 1988). Lean dry samples were ashed in a muffle furnace for 6 h at 550°C, and the proportion of ash in each was used to calculate ash for each constituent. Ash weight was subtracted from LDM to determine ash-free lean dry mass (AFLDM), a measure of total body protein.

To account for variation in carcass and component masses (lipid, AFLDM, ash) related to structural size, we used the correlation matrix from bill height, bill width, culmen, tarsus, wing chord, wing, body, and keel lengths in a principal components analysis (PCA) of all adults combined. From this we obtained scores for each bird along the first component axis (PC1) to use as an index of structural size (Alisauskas and Ankney 1987). PC1 accounted for 55% of variation in the characters measured, with a corresponding eigenvalue of 4.44. Loadings on the first principal component were all positive and ranged from 0.15 for culmen to 0.44 for wing chord. PC1 scores for individual ducks were used as covariates in analyses of covariance (ANCOVA) comparing lipid, ash, and protein dry weights between sexes. This technique accounts for variation between sexes that occurs as a result of differences in body size (Alisauskas and Ankney 1987) and allows comparison of relative amounts of lipid, ash, and protein. We also compared our data to those from Peterson and Ellarson (1979).

RESULTS

Male Oldsquaws were larger than females in most external morphological measurements (Table 1). Masses of esophagus, heart, liver, and

TABLE 1

MEANS OF MORPHOLOGICAL VARIABLES FOR ADULT OLDSQUAWS COLLECTED IN OCTOBER 1986 IN NORTHEASTERN ONTARIO^{ab}

Variable	Males (N = 15) ^c	Females (N = 12)
Whole body mass	862.8 (17.9)A	733.6 (11.6)B
Carcass mass	633.0 (16.8)A	573.5 (12.7)B
Body length	342.1 (2.5)A	320.1 (3.5)B
Wing length	327.9 (1.6)A	313.8 (1.3)B
Wing chord	223.2 (1.1)A	210.2 (1.1)B
Tarsus	35.6 (0.3)A	34.7 (0.3)B
Culmen	27.1 (0.3)A	26.5 (0.4)A
Bill height	16.4 (0.3)A	15.9 (0.3)A
Bill width	19.7 (0.2)A	18.2 (0.2)B
Keel length	109.2 (1.0)A	100.6 (0.6)B
PC1	1.68 (0.3)A	-1.99 (0.2)B

^a Linear measurements in mm, mass in g, standard error in parentheses.^b Means followed by the same letter are not different between sexes, *t*-test, $P > 0.05$.^c $N = 13$ males for variables that include the head; two males were decapitated when found.

gizzard differed between sexes (Table 2) but not when PC1 was included as a covariate (ANCOVA, $P > 0.05$ in all cases). AFLDM and ASH were positively related to structural size and did not differ between sexes when PC1 was included as a covariate (ANCOVA, $P > 0.30$), although both were absolutely larger in males. There was no relationship between total

TABLE 2

MEAN LENGTHS AND FRESH MASS OF INTERNAL ORGANS OF ADULT OLDSQUAWS COLLECTED IN NORTHEASTERN ONTARIO IN OCTOBER 1986^{ab}

Organ	Males (N = 15)	Females (N = 12)
Small intestine length	133.9 (4.1)A	128.6 (4.2)A
Mass	17.0 (0.9)A	15.5 (0.6)A
Large intestine length	6.6 (0.2)A	6.7 (0.2)A
Mass	1.5 (0.1)A	1.3 (0.1)A
Caecum length	12.4 (0.6)A	11.1 (0.6)A
Mass	0.7 (0.1)A	0.8 (0.1)A
Esophagus mass	8.1 (0.3)A	6.8 (0.2)B
Gizzard mass	17.0 (2.2)A	10.1 (1.2)B
Heart mass	10.5 (0.2)A	6.9 (0.2)B
Pancreas mass	2.4 (0.2)A	1.8 (0.2)A
Spleen mass	0.34 (0.07)A	0.34 (0.07)A
Liver mass	32.3 (1.6)A	25.7 (1.2)B

^a Masses measured in g, lengths in cm, standard error in parentheses.^b Means followed by the same letter are not different between sexes, *t*-test ($P > 0.05$).

TABLE 3
MEAN MASS OF CARCASS COMPONENTS OF ADULT OLDSQUAWS COLLECTED IN
NORTHEASTERN ONTARIO IN OCTOBER 1986^a

	Lipid	AFLDM	Ash
Males ^b			
Breast	2.26 (0.15)	19.97 (0.35)	—
Leg	1.56 (0.13)	5.06 (0.11)	—
Liver	0.89 (0.11)	9.46 (0.55)	—
Homogenate	117.20 (7.64)	105.84 (3.70)	19.87 (0.93)
Dry parts	15.56 (0.57)	29.42 (1.17)	7.71 (0.17)
Total	141.46 (8.39)	172.40 (4.51)	28.27 (0.95)
Females			
Breast	1.94 (0.10)	17.34 (0.29)	—
Leg	1.33 (0.09)	4.46 (0.10)	—
Liver	0.64 (0.09)	7.67 (0.36)	—
Homogenate	124.60 (6.78)	80.08 (2.82)	15.99 (0.45)
Dry parts	13.19 (0.68)	23.99 (0.51)	6.48 (0.17)
Total	141.70 (7.00)	133.56 (2.92)	22.48 (0.47)

^a Mass in grams (g), standard error in parentheses.

^b *N* = 13 males for "dry parts" and "total" values because 2 males were decapitated when found.

lipid mass and body size (ANCOVA, $P > 0.75$). Furthermore, total lipid mass was almost identical between male and female Oldsquaws (Table 3) despite the smaller structural size of females. Lipids comprised 17.5% of whole body weights of females and 14.1% of males.

DISCUSSION

Oldsquaws nest in tundra habitats of southwestern Hudson Bay, and a migration corridor between James Bay and the Great Lakes has been postulated (Bellrose 1978). We found little published information on external morphological measurements and gut morphology of Oldsquaws, but we assume that our sample was unbiased and therefore representative of Oldsquaws that migrate through northeastern Ontario. Gut measurements were shorter than those reported by Goudie and Ryan (1991: Table 2) for a combined sample of male and female Oldsquaws collected in coastal Newfoundland during winter. Oldsquaws in Newfoundland fed mostly upon amphipods and isopods, but the diet of Oldsquaws staging in James Bay is unknown.

Mean carcass mass of fall migrant female Oldsquaws was similar to that of spring migrants, and about 70–200 g greater than that during mid-summer and winter (Peterson and Ellarson 1979). Most seasonal variation in carcass mass of adult females was attributable to fluctuations in lipid

levels; protein reserves (as indexed by LDM) were about 25 g heavier during fall migration than in mid-summer but about 15 g less than in spring. Carcass mass of males was similar in spring and fall; lipid levels also were similar in spring and fall. Inexplicably, male Oldsquaws had about 25 g more protein reserves in fall than in spring (Peterson and Ellarson 1979).

Peterson and Ellarson (1979: Table 1) reported that adult female Oldsquaws lost about 95% of lipid reserves and 30% of LDW between spring migration and the start of brood rearing in late July. Our data indicated that fall migrant female Oldsquaws had lipid levels similar to those of spring migrants, but protein reserves were 11% smaller. This suggests that (1) substantial increases in lipid and protein stores occur between late July and October and that (2) female Oldsquaws increase protein reserves in spring, perhaps for egg production.

Carcass lipids of adult female Oldsquaws on Lake Michigan in December were about 44 g less than, and protein reserves were about equal to those of fall migrants, suggesting that lipids provided energy during migration. Peterson and Ellarson (1979:294) estimated that a migrating Oldsquaw metabolized about 25.76 kcal/h. Assuming stored fat yields 9.45 kcal/g and conversion efficiency is 100%, 44 g of fat yields enough energy to fly for about 16 h. If Oldsquaws fly at an average speed of about 80 km/h (Bellrose 1978: 385), an average female in our sample could travel about 1280 km on 44 g of fat. Carcass lipids of adult males followed the same pattern as females, averaging 47 g less in winter than in fall. In addition, they had about 25 g more lean dry mass in fall than birds sampled in December. The nearest wintering areas for Oldsquaws from lower James Bay are the lower Great Lakes, i.e., southern Lake Michigan, Lake Erie, and Lake Ontario (Bellrose 1978). As none of these locations is >1280 km from lower James Bay, Oldsquaws had more than sufficient reserves to reach those destinations. Our data suggest that off-shore habitats in James Bay and Hudson Bay are important to postbreeding Oldsquaws for replenishment and storage of protein and lipid reserves before fall migration.

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